SAHRV Modem P31
And
SAHRV Modem P31 System Integration
Continuation of Contract N00014-01-C-0419

Lee E. Freitag
Christopher von Alt
Woods Hole Oceanographic Institution
86 Water St., MS#18
Woods Hole, MA 02543
Phone: (508) 289-3285 Fax: (508) 457-2195
email: lfreitag@whoi.edu
http://acomms.whoi.edu/

Award Number: N00014-01-C-0419

LONG-TERM GOALS

The long-term goals of our acoustic communications efforts are to better understand the underwater acoustic communication channel and the performance of acoustic communication signals under conditions representative of acoustic links useful for AUVs and Navy vessels. This work includes development of modulation methods, design of receiver strategies, work on error-control coding, optimization of system components for different applications, and other related work.

OBJECTIVES

The objective of this project was to transition WHOI acoustic communications technology into a production-ready system for use by the Navy. The Pre-Planned Product Improvement (P3I) program specifically included several technologies, including forward-look sonar and acoustic communications. Our work focused on the acoustic communications technology with the goal of complete integration into REMUS/SAHRV (Semi-Autonomous Hydrographic Reconnaissance Vehicle).

APPROACH

The approach extended the work done under other ONR programs, specifically the Very Shallow Water and Surf Zone Mine Countermeasure (VSW/SZ MCM) Program, which started in 1997. During this program we developed the WHOI Micro-Modem and demonstrated it with the Utility Acoustic Modem (UAM) during several years of field testing. The Micro-Modem was installed on WHOI REMUS vehicles after several successful demonstrations with the UAM. The first integration was described in [1], and the system was demonstrated in Italy in a joint battle-space preparation experiment with SACLANTCEN (now NURC).

The integration of the modem with the SAHRV version of the REMUS vehicle was performed by the Oceanographic Systems Laboratory and the Acoustic Communications Group at WHOI. OSL was responsible for physical integration, AUV software development, and electrical interfacing. The Acoustic Communications Group developed the modem itself and performed extensive testing both before and during the integration period. The final product for the project was delivery of

documentation to Hydroid as part of a technology transfer of the communications capability for use on the REMUS vehicles including the SAHRV.

WORK COMPLETED

The work performed under this contract included a significant amount of development and integration work that is described in greater detail below.

- **Physical Installation on REMUS.** The modem was installed as shown in Fig. 1. It is on the side of the chassis that holds the REMUS motherboard, thus leaving free valuable space on the top of the motherboard where the CAD/CAC computer and other sensor processors are located. The modem fits on top of an interface card that provides a mechanical transition to inserts on the chassis and the electrical interface to the LBL system.
- **Electrical Integration on REMUS.** The REMUS vehicle has a long baseline acoustic navigation system with transducer and power amplifier. To avoid adding redundant hardware, both of these subsystems are used by the modem. A small interface card is used to transition the signals to and from the Micro-Modem DSP board and the LBL board. The LBL board provides the pre-amplified, received signal from the transducer and it accepts the modem transmit signal and an enable line to turn on the transmitter. The receive transponder function of the LBL system is blanked and cannot receive when the modem transmits, but because it is operated at a relatively low duty cycle, the number of missed interrogations from the surface is low.
- **Physical Integration into the REMUS Ranger.** The REMUS Ranger is the small, hand-held over-the-side tracking system that is supplied with all vehicles. It interrogates the LBL receiver on the vehicle to get range, and has the capability to send several codes. The codes are short, broadband signals that are used to start and stop the mission. The Ranger has a small alkaline battery that is used to charge a capacitor that holds enough energy for a very short ping, but it does not have the capacity to transmit an acoustic communications signal. Thus the modem installed into the Ranger is just a Mico-Modem DSP card that has a tap into the received signal on the transponder electronics as shown in Fig. 2.
- **REMUS Ranger Telemetry.** The Ranger only has the capability to display two lines of text on its LCD screen. Thus there is a limited amount of data that needs to be transmitted. A new CCL message [2] was developed to hold the information that could be displayed, and it is coded in a format that is easy for the transponder processor to prepare for display on the LCD screen. Table 1 summarizes some of the parameters that are transmitted by the vehicle to the Ranger.
- **Small Boat Modem.** The vehicle interface program (VIP) runs on a laptop and connects to the modem over a serial port. The VIP has a mode that works effectively with the topside modem to display status that is sent by the vehicle. It also has a command interface that is used to send re-direct messages to change the behavior of the vehicle. The modem designed for field use is called the Rigid-Hull Inflatable Boat (RHIB) modem. It is in a sealed pressure vessel, which is submersible to 225 ft (100 psi) and has an internal Lithium Ion battery that can be charged inside the pressure housing without opening it. The unit is very rugged (see Fig. 3) and can be used for many days without charging.

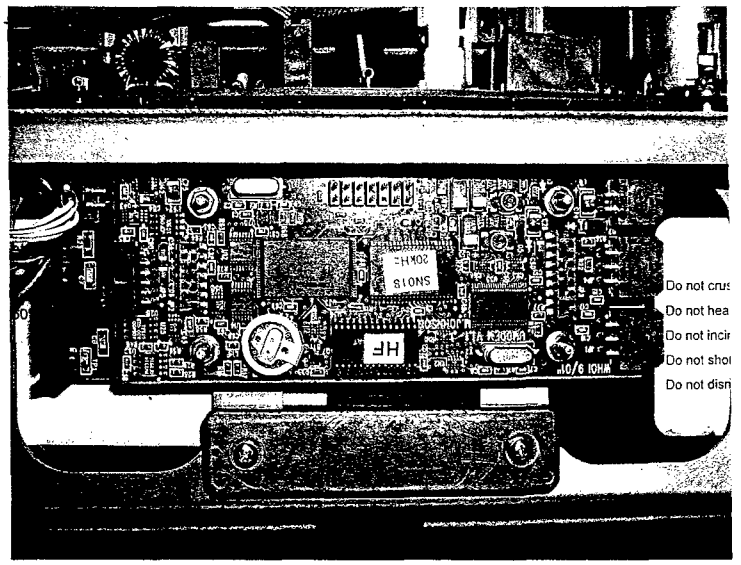

Fig. 1. Micro-Modem DSP board in REMUS

Table 1. Data transmitted to Ranger

Data Type	Number of Bytes (BCD)
Latitude/Longitude	8
Depth (meters)	2
Leg N of M	3
Percentage of Leg completed	1
Time Remaining (HH:MM)	2
Percent battery remaining	1
Battery minutes remaining	2
Estimated velocity	2
Vehicle heading	3
Mode	1 (bitwise code)
Bitwise Faults	1 (bitwise code)
Total Bytes:	26

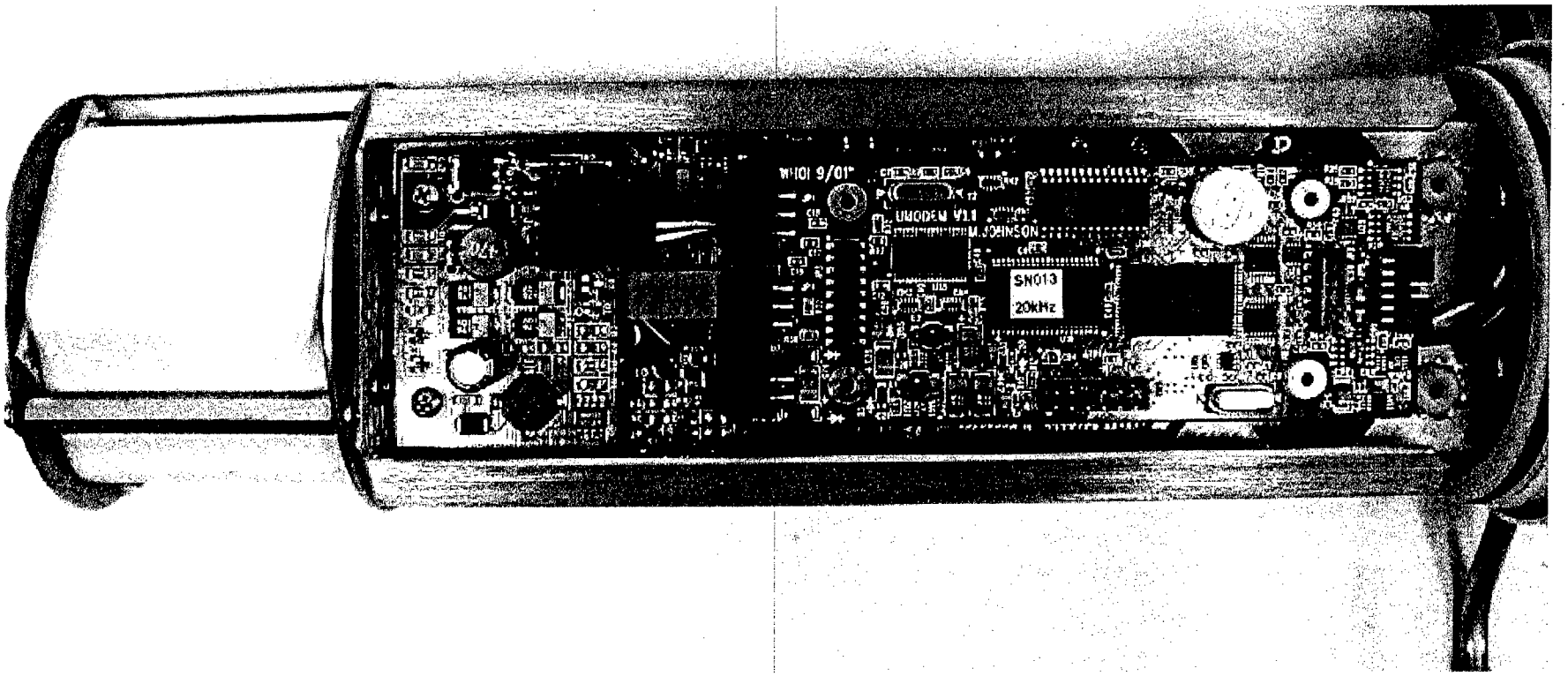

Fig. 2. Micro-Modem DSP board installed in REMUS Ranger

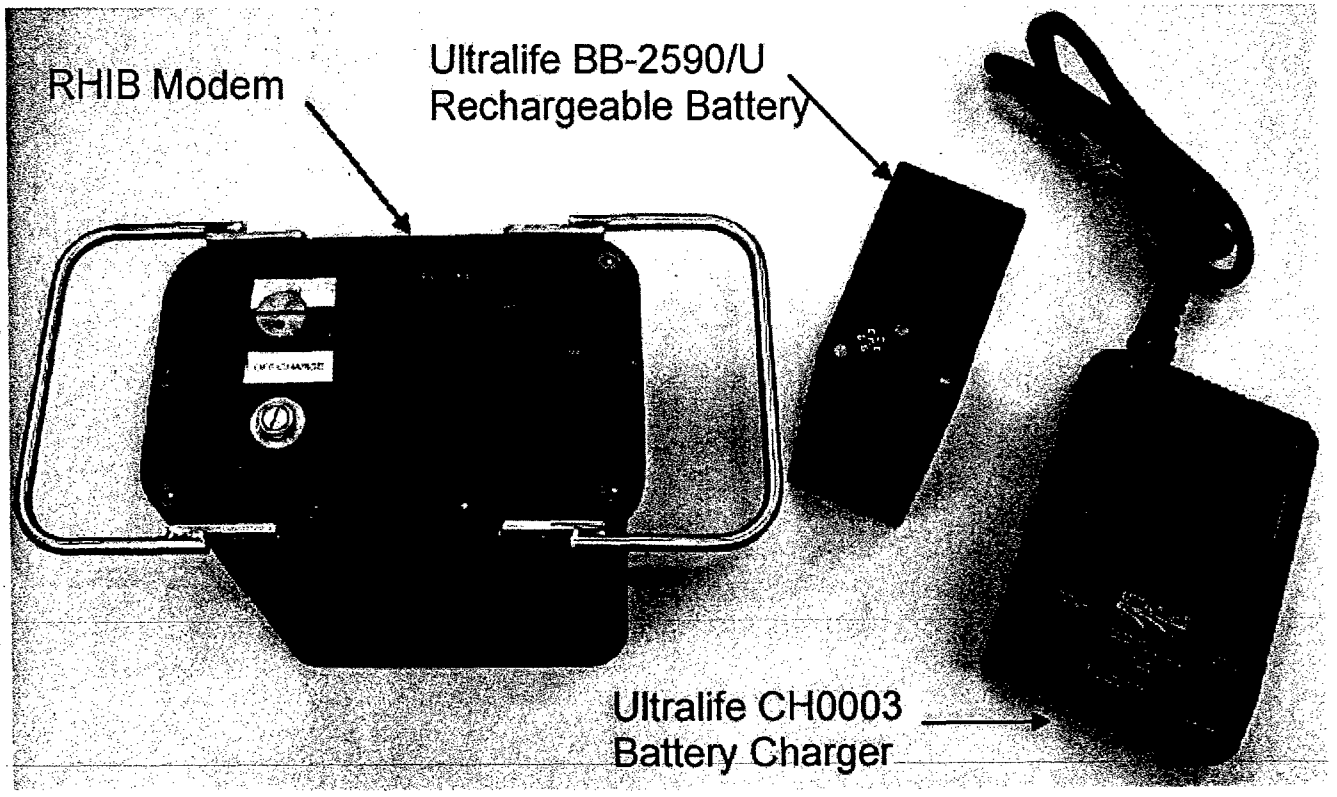

Fig. 3. RHIB modem and charger.

RESULTS

The modem was integrated in several WHOI REMUS vehicles and then into several of the SAHRV class vehicles that are operated by the Navy Surface Warfare Center (NSWC), Panama City. Initial testing was performed by WHOI and then independent tests were conducted in Panama City and at AUV Fest in Keyport (2003). An example of the test geometry is shown in Fig. 4. The range for the communications system was tested to 2000 m and was demonstrated to be reliable under most acoustic conditions.

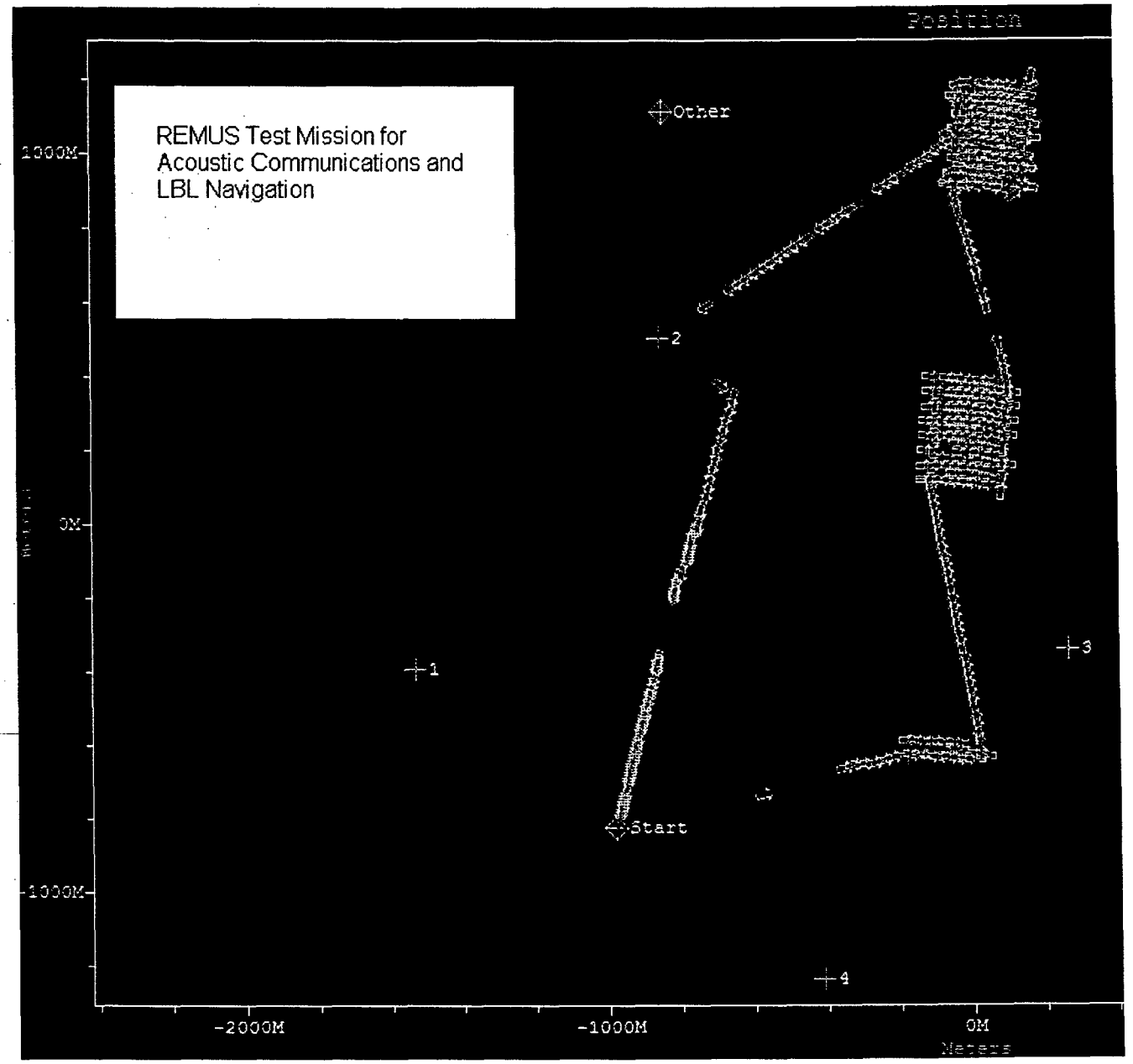

Fig. 4. REMUS test mission geometry.

IMPACT/APPLICATIONS

The WHOI Micro-Modem has been successfully integrated into the REMUS vehicle. As a result of the SAHRV P3I program, REMUS is now available to both the Navy and to civilian scientists with an acoustic communications capability. It will find applications in MCM operations as well as oceanographic mapping and sampling where real-time telemetry can be used to monitor mission progress and make decisions about data quality in real-time.

TRANSITIONS

The transition for portions of this work has been done. A license for production of the Micro-Modem has been set up with Hydroid Inc, the manufacturer of the REMUS and SAHRV class of vehicles.

RELATED PROJECTS

Acoustic Communication and Navigation for Very Shallow Water and the Surf Zone: fiscal year 2005. Woods Hole Oceanographic Institution. PI: Lee Freitag. Contract No. N00014-99-1-0287.

Undersea Acoustic Communication and Navigation Technology Development and Demonstration (Part of the Autonomous Operations FNC). Woods Hole Oceanographic Institution. PIs: Lee Freitag and James Preisig. Contract No. N00014-02-C-0201.

REFERENCES

[1] Freitag, L., M. Grund, S. Singh and M. Johnson, "Acoustic communication in very shallow water: Results from the 1999 AUV Fest," *Proc. Oceans 2000*, Providence, RI, Vol. 3, pp. 2155-2160, 2000.

[2] Stokey, R., L. Freitag, M. Grund, "A Compact Control Language for AUV Acoustic Communication", *Proc. Oceans 2005 Europe*, Brest, France. June 2005.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From – To)*
09/08/05	Final Report	22-Aug-02 – 30-Sept-04

4. TITLE AND SUBTITLE
SAHRV Acoustic Modem P3I and SAHRV P3I System Integration

5a. CONTRACT NUMBERS

5b. GRANT NUMBER
N00014-01-C-0419

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

Lee E. Freitag, Christopher von Alt

5d. PROJECT NUMBER
WHOI 100419SP

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Applied Ocean and Physics and Engineering Dept.
Woods Hole Oceanographic Institution
86 Water St., MS#18
Woods Hole, MA 02543

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

Dr. Thomas Swean
Office of Naval Research
One Liberty Center
875 North Randolph Street, Suite 1425
Ocean Engineering & Marine Systems (321OE), Rm. 1092
Arlington, VA 22203-1995

Eric Garfield
Administrative Contracting Officer
ONR Boston Regional Office
495 Summer Street
Boston, MA 02210-2109

Defense Technical Information Center
8725 John J. Kingman Road STE 0944
Ft. Belvoir, VA 22060-6218

Naval Research Laboratory
ATTN: CODE 5227
4555 Overlook Avenue SW
Washington, DC 20375-5320

10. SPONSORING/MONITORING ACRONYM(S)

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION/AVAILABILITY STATEMENT

Approved for public release; distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT

See Attached

15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON Lee E. Freitag
a. REPORT Unclassified	b. ABSTRACT Unclassified	c. THIS PAGE Unclassified	None		19 b. TELEPHONE NUMBER *(Include are code)* 508-289-3285

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI-Std. Z39-18